Summary of the Principles of Hierarchy Theory

S.N. Salthe

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Hierarchy theory has two known forms:
(**a**) the scalar hierarchy (including a synchronic map of the command hierarchy)
(**b**) the specification hierarchy (including a diachronic model of the trajectory of a given command). The Linnaean hierarchy in biological systematics has this form.

General properties:

In both of these forms, when used to model systems, higher levels (control, regulate, interpret, harness) lower levels, whose behaviors are made possible by properties generated at still lower levels. So, higher levels provide boundary conditions on the behaviors of lower levels -- behaviors initiated by still lower level configurations. (It is important to realize that few users of hierarchical forms would insist that particular levels exist in actuality. Levels are discerned from hierarchical analysis, aimed at constructing (discovering) Nature's "joints" with respect to given projects.)

(**a**) To use the scalar hierarchy we need to stipulate some focal level, as well as a lower and a higher, making up a basic triadic system -- as, e.g., when the behavior of living cells is initiated by chemical events, and controlled by organismic events. (This reflects the putative way in which levels would have evolved, by interpolation between primal highest and lowest ones.) The three level form insures stability because with it in place (a third level always anchoring relations between the other two), the focal level cannot be reduced either upward or downward by assimilation into a contiguous level. Here we should note that this hierarchy has been invoked to explain how the world manages to be as stable as it is.

(**b**) In the specification hierarchy the highest relevant level is always the one in focus, with all the lower levels of the hierarchy providing cumulative initiating conditions simultaneously upon it. (This reflects the fact that this hierarchy is implicitly developmental, with the levels being viewed as having emerged consecutively from the lowest, or most general, up -- as with, e.g., biology emerging from chemistry, both historically and at any given moment.) The two-level form is unstable, allowing new levels to emerge at the top of the hierarchy. Use of this form provides us a model of how change has been possible in the world.

Hierarchical analysis is always driven by a given problem or project.

Formal relations between levels:

(**a**) The scalar hierarchy is one of parts nested within wholes, as, e.g., [... [species [population [organism [gene [...]]]]]], where [higher level [focal level [lower level]]]. The logic reflects Russell's logical types. In principle the levels just keep going, receding at both ends from the focal level. (It may be noted that this structure probably is rooted in our visual experiences.)

If the parts are functional in some given analysis, they are referred to as components, if not they are constituents. As one goes down the hierarchy, the relative number of constituents per level increases.

(**b**) The specification hierarchy is one of classes and subclasses, as e.g., {material world {biological world {social world }}}, where {lower level(s) { highest level}}. The focus of analysis is always highest level, which is the innermost level of the hierarchy. The logic reflects Ryle's categories.

Style of growth of the hierarchy:

(**a**) The scalar hierarchy adds levels by interpolation between existing levels. In this way the system must be an expanding one. Therefore, an assumption required for use of this hierarchy is the Big Bang (or other expanding system). The actual process of formation of a level would involve the cohesion of entities out of lower level units guided by higher level boundary conditions. This process is little understood since this hierarchy has largely been used for synchronic analyses.

(**b**) In the specification hierarchy new levels would emerge from the current highest one. So this system too can grow -- but not in space. Growth here is by the accumulation of informational constraints, modeled as a process of refinement by way of adding subclasses.

Criteria:

(**a**) In the scalar hierarchy components at different levels differ in size roughly by orders of magnitude. This hierarchy is an extensional or quantitative construct.

(**b**) Levels in the specification hierarchy mark the qualitative differences of different realms of being, as in 'physical realm' versus 'biological realm'. It is an intensional construct, open at the top (the innermost level is unbounded above, and so free to give rise to ever higher levels).

Complexity:

(**a**) The scalar hierarchy provides a model of extensional complexity, the sign of which is nonlinear and chaotic dynamics, allowed by the fact that at any locale at any level in this hierarchy there could be a mixture of different kinds of information (relations, variables, constants of different kinds, attractors) which are not governed by a single overall structure.

(**b**) The specification hierarchy embodies intensional complexity, which characterizes a system to the degree that it is susceptible to many different kinds of analyses.

Dynamical relations:

(**a**) The scale hierarchy represents a single moment in space, so its dynamics represent homeostasis, not change. Large scale moments "contain" many small scale moments. It is often suggested that scalar levels fundamentally signal rate differences rather than component size differences. We may note that the two most often go together. The problem appears in cases that are said to be non-nested, where, e.g., a much slower rate in a component of a cycle would regulate the rate of the entire cycle. It would be rare, however, for such rates to differ by orders of magnitude, and so many of these examples are likely not hierarchical at all. If we allowed mere size differences rather than scale differences to be the criterion, then the constraint of nestedness would be lifted. In any case:

Because of the order of magnitude differences between levels in the scale hierarchy, dynamics at different levels do not directly interact or exchange energy, but transact by way of mutual constraint (i.e., via informational connections). The levels are screened off from each other dynamically and (more or less) adiabatically. Because of this, informational exchanges between levels are intransitive, requiring interpretation at the boundaries between levels.

So, if focal level dynamics are represented by variables in an equation, then the results of dynamics at contiguous levels are represented by (nonrecursive) constants. Higher scale dynamics are so slow with respect to the focal level, that the current value of their momentary result appears relatively unchanging at the focal level. Cumulated results of lower scale dynamics also appear relatively unchanging at the focal level, as it takes a very long time in lower scale moments to effect a change detectable at the focal level -- these points are the essence of 'screening off'.

Note that, because of these relations, thermodynamic equilibria would be more rapidly achieved the lower the scalar level, delivering an adiabatic principle relating to screening off. While change of any kind (development, acceleration, diffusion) is more rapid at lower levels, absolute translational motion is more rapid at higher levels (it would not, of course, be detected by lower level constituents, and so tends to be irrelevant in this hierarchy). Related to these matters, we should note that metabolic rates and development are much faster in smaller dissipative structures (including organisms), and their natural life spans are shorter. One sometimes sees the term heterarchy, posed in opposition to the scale hierarchy because of supposed failures of actual systems to conform to hierarchical constraints. One needs to recall here again that hierarchy is a conceptual construction, an analytical tool, and use of it does not imply that the world itself is actually hierarchically organized. It does seem to be in many ways, but to suppose that this is the sole principle needed in understanding the world would be naive. It is one tool among many. But often this opposition is based merely on faulty understanding. For example, the tides are affected (partially controlled) by gravitational effects associated with the moon; yet the oceans are not nested inside the moon. As in classical thermodynamics, it is important to see the whole system correctly. The oceans are nested, along with the earth itself, within the solar system, and from the hierarchical point of view, these effects on the tides emanate from the solar system, not merely from the moon.

(Demurrer: As we descend in applications through the realm of fundamental particles, it may be that many of these rules would break down [via nonlocality, etc.]. Hierarchical constructs model events in the material world, defined as the realm of friction and lag in the affairs of chemical elements and their compositions.)

(**b**) Dynamics in the specification hierarchy are entrained by development, which is modeled as a process of refinement of a class or category. It is important to note that this process is open-ended in the sense that there could be many coordinate subclasses of a given class. That is, the potentials arising within any class form a tree. So, {physical realm { material realm { biological realm }}}, or {mammal { primate { human }}} each follow just one branch of a tree. Rylean categories can branch into new distinctions (and this forms a link with the scalar hierarchy because this would give rise to new logical types). Evolution (unpredictable change) is one -> many, and so we can picture organic evolution using the Linnaean hierarchy.

The fact that formally this is a two-level hierarchy makes it susceptible to change, because, without the anchoring provided by a third level, it can logically be reduced to a single level. How is its direction into new subclasses insured (giving rise to the hierarchy)? In the material world by the fact that information, once in place (or once having had an effect), marks a system irrevocably. If a system continues to exist, it must march forward if it changes. (Since change in the material world is entrained by the Second Law of thermodynamics, we have here another link between hierarchies because the Second Law is a result of the universal expansion being too fast to allow global equilibration. As noted above, this expansion is what affords the interpolation of new scalar levels.)

So, development of a specification hierarchy requires a two-level basic form. Yet these hierarchies involve more than just two levels. Why do not the more general levels prevent change, as by the weight of their accumulated information? Here we are led to note another aspect of development, which is perfectly general. The amount of change required to launch a new level is ever smaller as the hierarchy develops -- refinements are just that. The more general levels do exert their influence; biology is a kind of chemistry, and humans are a kind of mammal. The key to understanding this situation is that in the specification hierarchy informational relations between levels are transitive. This means that there are functionally just two levels at work anywhere in the hierarchy -- and new levels may branch off anywhere in the hierarchy, potentially giving rise to collections of coordinate classes.

Informational relations and semiotics:

(**a**) As noted above, informational relations between scalar levels are intransitive. The levels are screened off from each other dynamically, and influence each other only indirectly, via informational constraints. But signals moving from one level to another are transformed at boundaries between the levels. When this is not the case, as when a signal from a higher level occasionally transits to a much lower level, that level suffers damage (as when an organism is hit by lightning, or, going the other way, if a given cell affects the whole organism, this could only be by way of the likes of cancer) -- we can recall again the idea that scalar levels deliver stability to a system, via the screening off effect.

The interpolation of a new level between two others can be viewed as involving the appearance of a capability at the uppermost level (via fluctuation, self-organization and/or selection) for making a significant (to it) interpretation of events at the lowermost level of the three. The upper level effectively disposes -- facilitates cohesion among -- some of what the lower level proposes. This requires energetic screening off between levels. As the arena of the upper level's interpretants, the new level acts as a filter or buffer between upper and lower. This allows us to see levels succeeding each other by a classification procedure whereby topological difference information is converted to (coheres as) typological distinction information in an essentially top-down procedure.

(**b**) In the specification hierarchy the lower levels also make possible the emergence of a new realm, in an epigenetic process. And here too the process is top-down, but in a different sense, involving finality. Thus, as organism sociality implies biology, and biology implies chemistry, so, because this is a process of refinement, only a very narrow set of possibilities could imply organism sociality. That is, chemistry could give rise to many kinds of supersystems, biology to fewer, and sociality to even fewer as the epigenetic system develops. Developments (in distinction from evolution) are always entrained by final causes, and approach them asymptotically with each emergence of a new realm. Involved here, as in all developments, is the process of senescence, a condition of information overload (recall that information in this hierarchy is transitive across levels), leading to overconnectivity, leading in turn to functional underconnectivity, leading in its turn to inflexibility and habit driven responses (loss of requisite variety), leading ultimately to loss of adaptability (inability to produce interpretants of novel situations).

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The following sources emphasize the historically important, logically basic, and recent references that seem to me to bring in new departures.
* References starred deal with the specfication hierarchy, either exclusively or along with the scale hierarchy.

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